Experimental Removal of Lake Trout in Swan Lake, MT: 3-year Summary Report

Photo courtesy of The Daily Interlake

Prepared for the Swan Valley Bull Trout Working Group

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Table of Contents

List of Tables

List of Figures

Abstract

A recently established population of lake trout *Salvelinus namaycush* in Swan Lake, Montana is of concern because of potential threats to the recreationally popular kokanee salmon *Oncorhynchus nerka* and ecologically important bull trout *Salvelinus confluentus* fisheries. Research efforts since the initial discovery of lake trout in the Swan River drainage have been focused on lake trout population demographics, spawning locations, and potential lake trout suppression scenarios. In June 2009, Montana Fish, Wildlife & Parks (FWP) released an environmental assessment for a three-year experimental removal of lake trout in Swan Lake. From 2009-2011, a total of 21,330 lake trout from 6-36 inches long were removed from the lake. Lake trout catch per net increased between 2009 and 2010, then decreased in 2011, suggesting that netting efforts were effective at reducing recruitment of young cohorts of lake trout into successive age classes. Additionally, catch of predominantly newly recruited lake trout in 2010 and 2011 supported the notion that annual netting was effective at reducing abundance of juvenile lake trout. Analysis with regard to exploitation rates revealed that netting mortality rates of juvenile lake trout were higher than literature suggests are sustainable. Results from netting targeting adult lake trout were similar, though additional years of data would increase confidence in the analysis. Bycatch of fish species other than lake trout was relatively low throughout the project. However, despite efforts to minimize bycatch mortality (i.e., timing of netting, location of nets, reviving captured fish, etc.), the inadvertent catch and associated mortality of bull trout remains a concern. This concern is compounded by an observed decreasing trend of adult bull trout abundance (reflected by redd counts) in recent years in the Swan drainage. Analysis of the potential impacts the netting bycatch is having on the bull trout population suggests that while effects are possible, they are likely not sufficiently large to be solely responsible for the recent trend. Lake trout competition and/or predation is also suspected to be playing a key role as well as angler harvest. This trend will be closely monitored in upcoming years. Much information has been gained through this three-year experiment with regard to our effectiveness in affecting year to year lake trout cohort strength while minimizing impacts to other fish species. However, the effect this action has had on the overall lake trout population within the 3 year term remains uncertain. Therefore, it is recommended that the project be continued for a sufficient period to realize the effects from the previous actions. Determining the feasibility of the use of gill nets as a tool to effectively reduce the lake trout population will provide fisheries managers alternatives for the long-term management of Swan Lake and other waters.

Background

The Swan Valley has historically been home to a stable bull trout population. However, in 1998 anglers began to occasionally catch adult sized (20-30 inch) lake trout from Swan Lake and the Swan River. This caused alarm because lake trout are not native and are notorious for rapidly expanding and dominating fish communities in lakes with *Mysis* shrimp, particularly at the expense of bull trout and kokanee salmon (Martinez et al. 2009). In 2003, the level of concern was compounded when biologists gillnetted juvenile lake trout from Swan Lake during standard low-intensity sampling efforts, indicating that wild reproduction was occurring. Since 2003, lake trout catch by anglers as well as during Montana Fish, Wildlife and Parks (FWP) biological sampling continued to increase, indicating that the population was expanding. Research efforts since 2006 have focused on lake trout population demographics, and exploring potential techniques to reduce lake trout numbers while minimizing bull trout bycatch. Based on case histories from nearby waters, long-term management alternatives for this increasing lake trout population are necessary in order to maintain the popular bull trout and kokanee fisheries.

In June of 2009, FWP released an environmental assessment (EA) detailing plans for a three-year experimental removal of lake trout in Swan Lake. This report provides a summary of results from the three-year experimental suppression project. Measurable goals and specific success criteria outlined in the EA will be used to evaluate the feasibility and effectiveness of alternatives to control expansion of the lake trout population. Based on the results of this assessment and other relevant considerations, FWP, with recommendations from the Swan Valley Bull Trout Working Group (SVBTWG), will consider whether these actions are appropriate or if other changes are warranted in fisheries management of Swan Lake and the lake trout population.

Previous annual reports can be found at www.montanatu.org, under the “Swan Valley Bull Trout Working Group” link.

Methods

Each year of the three-year experimental suppression project (2009-2011) was comprised of two distinct netting events. The first event (Juvenile Netting) was aimed at removing juvenile and subadult lake trout throughout the two deep (>60’) basins of Swan Lake. Removal was carried out primarily using small-mesh (1.5” – 3.0” stretch) gill nets, set by professional fisheries contractors over a three-week period beginning in late August. The nets were comprised of three, 900-foot panels of monofilament mesh, and were typically ganged to form a single 10,800-12,600’ net. Roughly half of the net panels were six-feet tall (full depth) and half were 3-4’ tall (low profile). The low profile nets were added to the array in an attempt to minimize bycatch of other fish species, as many times lake trout were captured in the bottom 1-2’ of net. Juvenile netting was conducted during a time in which most adult bull trout are upstream in the Swan River drainage in preparation for fall spawning and also occurred during the period in which Swan Lake is thermally stratified. Habitat below the thermocline (>60’) was netted uniformly, in order to reduce incidental bycatch of bull trout and other fish species which occupy shallower depths. An area surrounding the mouth of the river was avoided due to previously observed high concentrations of bull trout.

The second netting event (Spawner Netting) was directed at removal of adult lake trout during spawning and thus was targeted to directly affect further recruitment. This portion of the project was carried out largely by SVBTWG members and took place during the months of October and November. Large-mesh gill nets (3.5" – 5" stretch) were set during the night and early morning hours, along spawning areas identified by sonic telemetry work conducted from 2007-2009 (Cox 2010).

Hickey Bros personnel Tyler Long and Jack Tong remove lake trout captured during Juvenile Netting in Swan Lake.

Results

Juvenile Netting

Basin-wide netting throughout the three-year project was contracted with Hickey Bros. Fisheries of Baileys Harbor, Wisconsin. Each year the boat was cleaned and disinfected following a Hazard Analysis and Critical Control Point Plan (HACCP) to minimize the risk of spreading aquatic invasive species. The boat was inspected by FWP personnel prior to entering Swan Lake to ensure proper cleaning procedures had been followed. Consistent throughout the years, netting took place the last week in August through the second week of September, taking a short break over the Labor Day holiday to avoid disrupting recreational use. The contract with the Hickey Brothers required a total of 30 lifts (one lift being defined as an event comprised of setting the gill nets and retrieving the gill nets) annually. However, because additional small mesh net panels were added between years, the number of nets set annually increased (Table 1). Although the number of net panels increased throughout the three years, netting locations were similar for all years of the project (Figure 1). A total of 20,399 lake trout from 150-820 mm (approximately 6-32 inches) long were removed during the Juvenile Netting period from 2009-2011 (Figure 2). Total catch during Juvenile Netting increased from 2009-

2010, then decreased in 2011 (Figure 3). All fish less than 550 mm (22”) in length were cleaned, packed on ice, and sent to local area food banks for distribution. Fish greater than 22” were not retained for food bank distribution because of human consumption guidelines related to mercury content. Those fish were either given to local wildlife rehabilitation centers or were retained and used for wildlife research projects.

Attempts were made to keep fishing effort relatively consistent between years, with the noted exception of increased small mesh net panels. Fishing effort during the 2011 Juvenile Netting period was a replicate of the 2010 netting. However, in 2010 an additional smaller mesh size (1.75” low profile) was added to the array of nets in an attempt to capture smaller fish. The three-year average soak time for each mesh panel was 7.8 hours, and the average depth of nets was 99 feet. The depth was maximized and duration of these net sets was minimized within constraints of equipment and manpower in an effort to reduce bycatch and associated mortality of non-target species.

Table 1: Netting dates and effort expended during Juvenile Netting activities 2009-2011.

Year	Netting Dates	# Lifts	# 900’ Net Panels
2009	Aug 24-Sept 11	30	248
2010	Aug 23-Sept 10	30	311
2011	Aug 22-Sept 9	30	399

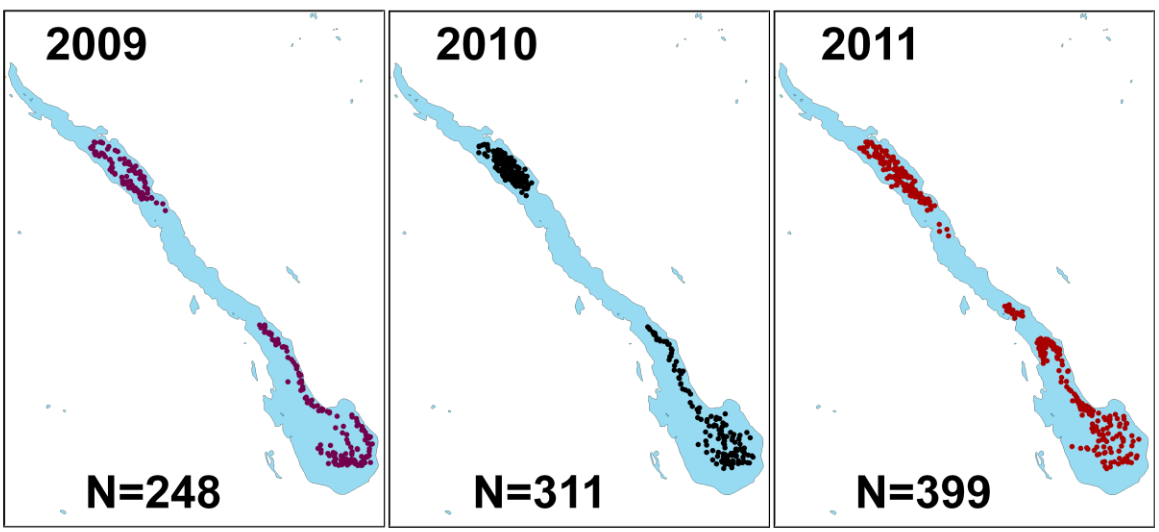

Figure 1: Locations and numbers of net panels set during Juvenile Netting activities 2009-2011.

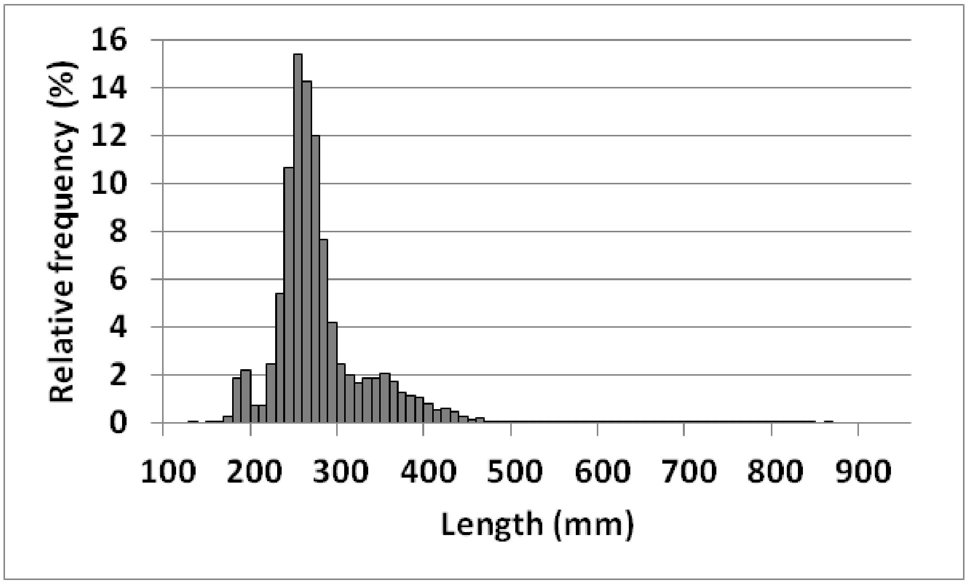

Figure 2: Relative length frequency of lake trout captured during Juvenile Netting activities 2009-2011.

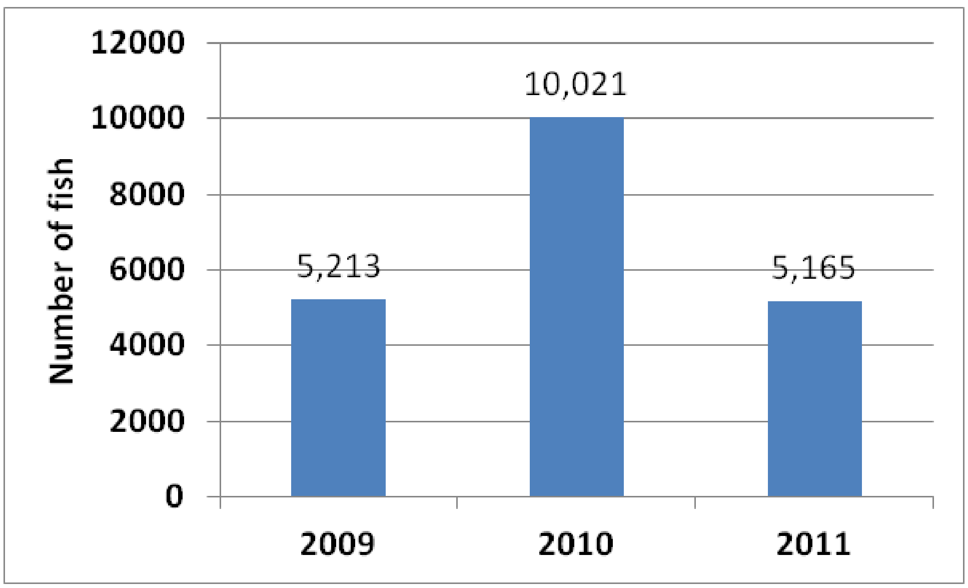

Figure 3: Total catch of lake trout during Juvenile Netting 2009-2011.

The overall length frequency distribution of lake trout caught during the Juvenile Netting period was skewed toward smaller fish (< 450 mm or 18 inches), as a result of targeting their location and fishing smaller mesh nets as the primary method (Figure 2). Throughout the three years, fish that were newly recruited to the gill nets (< 300 mm or 12 inches) comprised the majority (80.5%) of the catch during the Juvenile Netting period. Aging based on otoliths revealed that these fish are likely age-3 and age-4 lake trout (Cox 2010). When examined by year, relative length frequencies shifted toward smaller fish each year as cohorts were exploited (Figure 4). In 2009, multiple cohorts of juvenile lake trout were present in Swan Lake (including considerable numbers of age-

3,4, and 5 fish). However, the 2011 relative length frequency reveals that the catch was skewed toward age-3 fish newly recruited to the nets.

Lake trout catch per net decreased significantly overall in 2011 compared to 2010 (Figure 5). When examined by mesh size, lake trout catch per net decreased in 2011 throughout all mesh sizes, though this was only statistically significant for mesh sizes 2” and greater. Continued declines in lake trout catch per net for the 2.5” and 3” mesh suggest that efforts in 2009 and 2010 were effective in reducing their respective cohorts of age-3 and age-4 fish. The addition of the 1.75” mesh in 2010 resulted in increased catch of lake trout between 250 and 300 mm (10-12”).

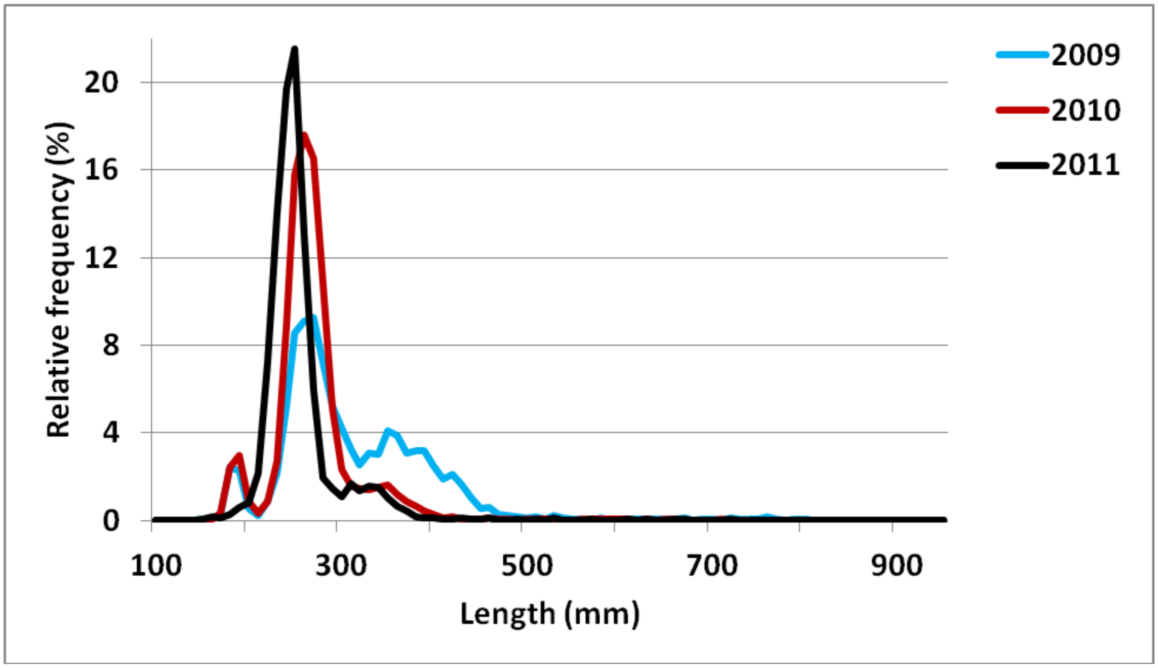

Figure 4: Relative length frequency by year of lake trout caught during the Juvenile Netting period 2009-2011.

Bycatch of fish species other than lake trout was relatively low throughout all years of Juvenile Netting given the amount of fishing effort (Table 2). Of all fish captured during Juvenile Netting, lake trout comprised 85% of the catch in 2009, 92% in 2010, and 90% in 2011. Netting locations (only water greater than 60’) allowed for targeted lake trout removal, while minimizing catch of other fish species, particularly rainbow trout, northern pike, and yellow perch that are more surface and shallow-oriented. The majority of the non-target bycatch was comprised of kokanee and bull trout, both ecologically and recreationally important fishes. All efforts were made to revive fish inadvertently captured in gill nets. Fish were held in Fraser recovery tanks with oxygen added to chilled flowing water in an attempt to increase survival prior to release. These techniques appeared to increase survival, however approximately 40% of gill net captured bull trout still died as a result of entanglement. A more complete analysis of bull trout bycatch and the potential population level impacts is discussed later in this document.

Table 2: Bycatch of non-target fish species captured during Juvenile and (Spawner) netting events 2009-2011. Most fish were released alive.

Fish Species	2009	2010	2011
bull trout	238 (26)	212 (87)	237 (104)
kokanee	205 (23)	414 (110)	159 (46)
mountain whitefish	107 (0)	28 (5)	31 (2)
pygmy whitefish	139 (0)	63 (0)	9 (0)
longnose sucker	86 (50)	49 (306)	65 (145)
northern pikeminnow	27 (36)	14 (136)	31 (131)
largescale sucker	0 (58)	0 (109)	0 (111)
rainbow trout	6 (3)	5 (10)	7 (11)
northern pike	0 (2)	0 (0)	0 (7)

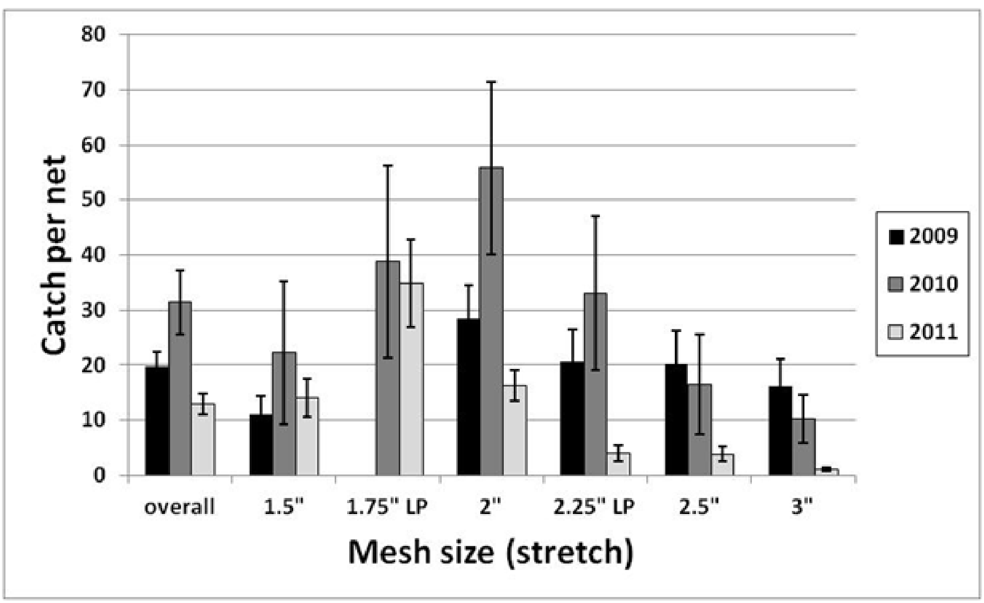

Figure 5: Lake trout catch per net for the Juvenile Netting period 2009-2011. Error bars represent 95% confidence intervals. LP indicates low-profile nets shorter than the standard 6-foot height.

A ripe female lake trout captured during Spawner Netting in Swan Lake.

Spawner Netting

Removal of the adult component of the lake trout population, in efforts to directly affect further recruitment of lake trout cohorts, began in 2009. Because this was the first year of the effort, several important considerations emerged. These included our need to better determine timing of the lake trout spawning period, optimal locations of nets set for spawning lake trout and ways to minimize bycatch of other fish species. Netting along predetermined spawning sites, discovered in 2007-2008 by implanting fish with sonic transmitters (Cox 2010), proved to be effective, with 239 mature lake trout captured over 16 nights in 2009. The majority of the 2009 lake trout catch was comprised of adult male lake trout (84%), which are suspected to spend more time in proximity to the spawning grounds, and suggested that timing or intensity of netting efforts during the peak of the spawn may have been insufficient to capture a greater proportion of the females. Therefore, netting efforts during the spawning period in 2010 were increased. In order to increase netting effort, while maximizing efficiency, we contracted with The Hickey Brothers Fisheries for the use of their gillnetting boat during the 2010 and 2011 Spawner Netting. SVBTWG members performed all netting duties under the guidance of the fishing vessel captain.

Netting during the lake trout spawning period from 2009-2011 resulted in a total of 931 mature lake trout being removed from the system. Similar to the Juvenile Netting results, lake trout catch during Spawner Netting increased in 2010 then decreased in 2011 (Figure 6). Spawning lake trout ranged in size from 508-914 mm (20-36”), with many fish greater than 610 mm (24 inches) in length (Figure 7). These fish are generally age-7 and older (Cox 2010). When examined by year, the relative length frequency of lake trout caught during the Spawner Netting period appears to have shifted toward smaller and younger fish, suggesting that efforts in 2009 and 2010 were effective in removing a considerable portion of the older and larger spawning fish and that new spawning cohorts were being recruited annually (Figure 8). Bycatch during the Spawner Netting period was comprised mostly of longnose and largescale suckers as well as northern pikeminnow (Table 2).

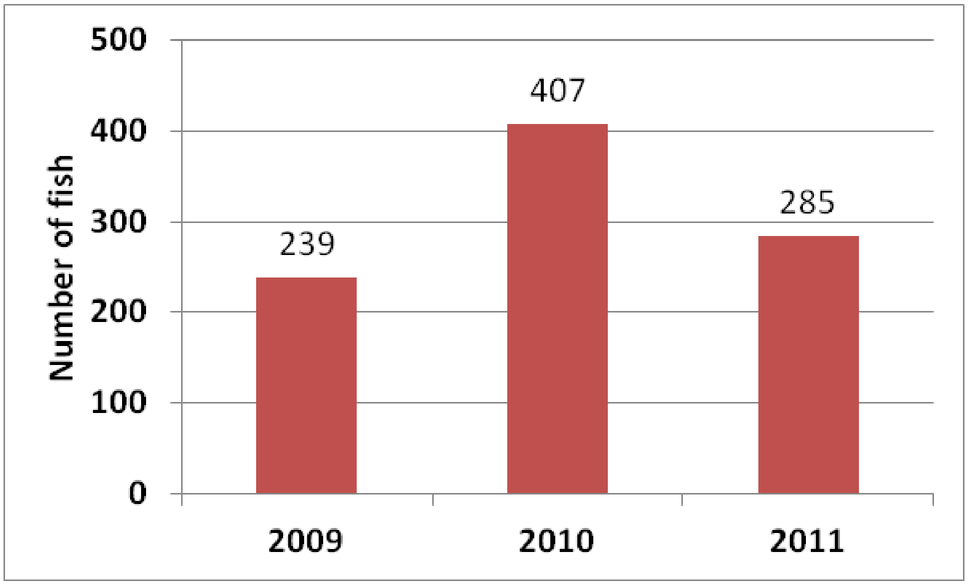

Figure 6: Total catch of lake trout during Spawner Netting 2009-2011.

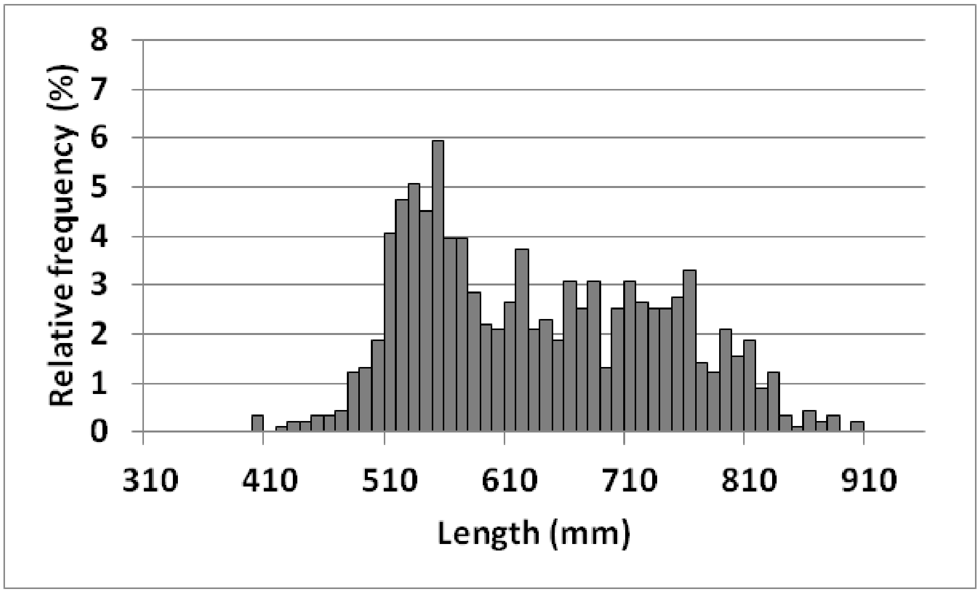

Figure 7: Relative length frequency of lake trout captured during Spawner Netting 2009-2011.

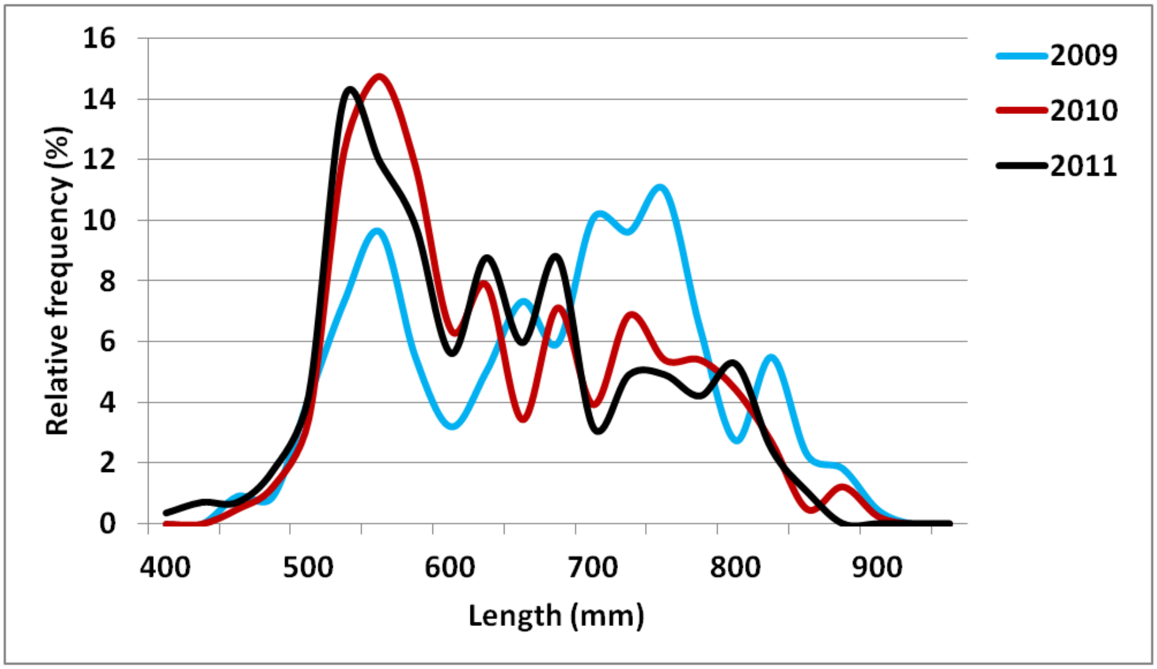

Figure 8: Relative length frequency by year for adult lake trout captured during Spawner Netting 2009-2011.

Identification of the exact timing of lake trout spawning is important in order to maximize removal efficiency. Initial netting of adult lake trout in 2009 increased our knowledge of the timing of spawning and led to a refined schedule and the use of the Hickey Brothers' boat equipped with a net-lifter from October 10 to October 22 in 2010 and 2011. This dramatically increased the amount of net we could fish as is reflected in the increased lake trout catch and bycatch. Throughout the three years of Spawner Netting, it was evident that adult male lake trout were present at predetermined spawning locations days before the females began to arrive (Figure 9). Catch of female lake trout increased throughout the second and third weeks of October and then tapered off toward the beginning of November.

The removal of 276 female lake trout from 2009-2011, the vast majority of which were still bearing their full complement of eggs, has the potential to reduce year-class strength in future cohorts. Cox (2010), in his M.S. research conducted on Swan Lake in 2008, calculated an average fecundity of 8,464 eggs per female. If 276 females had a similar average fecundity, they could produce 2.3 million eggs, most of which were removed from the system over the three years of this project.

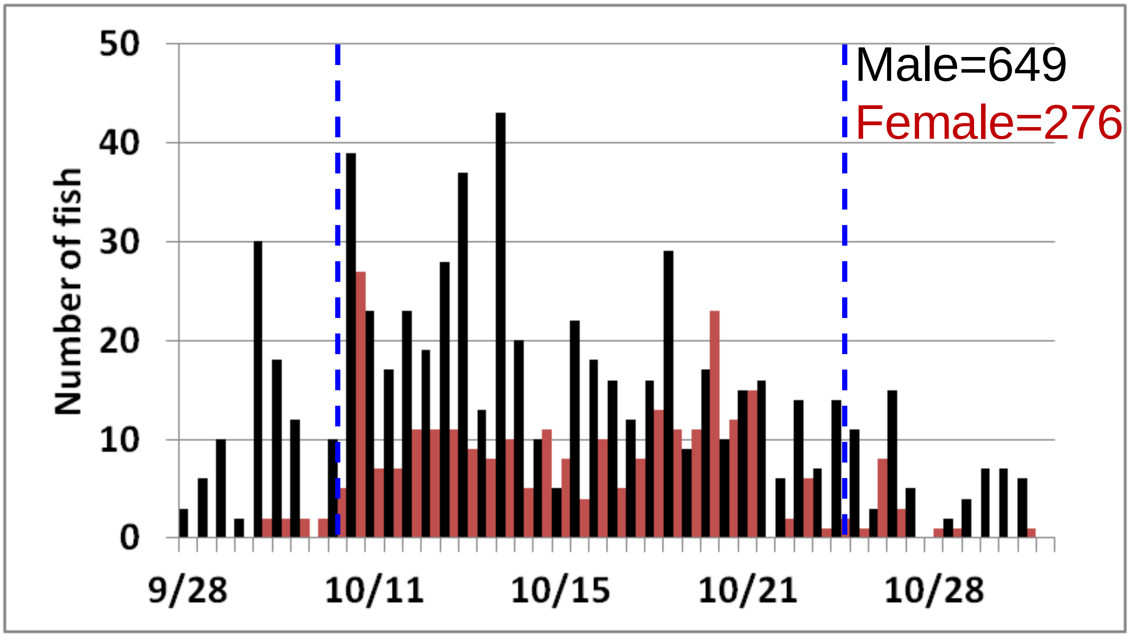

Figure 9: Combined lake trout catch throughout the Spawner Netting period 2009-2011. The blue dashed lines indicate the contracted period of netting from 2010-2011.

Hickey Bros president Todd Stuth holds a bull trout captured in Swan Lake.

Bull Trout Bycatch Analysis

Bull Trout Background and Swan Lake Population Dynamics

Because bull trout are listed as a threatened species under the U.S. Endangered Species Act (USFWS 1998), the USFWS has the lead role in monitoring, evaluating, and coordinating efforts to minimize bycatch of bull trout in Swan Lake associated with the lake trout suppression effort. Swan Lake is considered to be a bull trout "core area", one of over 100 core areas in the U.S. range of the species. Important tributaries to Swan Lake (e.g., Lion, Woodward, Elk, etc.) are considered to host “local populations” of bull trout, each supporting spawning and rearing (SR) habitat for genetically diverse and separately identifiable stocks of bull trout. Juvenile bull trout typically spend 1-3 years in their natal tributaries before emigrating downstream to Swan Lake. The mainstem Swan River and Swan Lake are considered foraging, migrating, and overwintering (FMO) habitat, where the separate local populations mingle to grow, mature, and develop prior to completing their life cycle. The bull trout population of the Swan is considered a migratory adfluvial population, meaning that individuals require both SR (tributary) and FMO (lake and river) habitat to complete their complex life cycle.

An extensive data base on Swan Lake bull trout populations has been collected, extending back to the early 1980s. A combination of research efforts and ongoing monitoring has resulted in a well-documented history of bull trout numbers, spawning locations, life history attributes, and other demographic information. We are using this information to our advantage, both in predicting impacts of lake trout expansion as well as to examine unintended consequences of bycatch from lake trout suppression efforts, angling, and other mortality sources.

In order to effectively suppress lake trout and not exert excessive mortality on bull trout or other important species (such as rainbow, cutthroat trout and kokanee) the lake trout removal effort has been carefully designed and constantly adjusted in both its timing and methods. We conducted a preliminary benefit/risk analysis for bull trout prior to implementing the 2007-2011 research and suppression efforts. At that time, we estimated an adult bull trout population of around 5,000 fish in the Swan Lake core area. We knew from extensive surveys that bull trout spawned annually at detectable levels in at least 10 Swan Lake tributaries. Figure 10 shows the trend in bull trout redd counts in those ten combined tributaries, since the time comprehensive basin-wide surveys began in 1995 (Weaver 2006 and FWP unpublished). Counts from the comprehensive basin-wide surveys do not monitor every single bull trout redd in the system, but are known (based on several even more extensive basin-wide searches) to represent the vast majority of spawning reaches (estimated 90% or more). These redd counts are thought to provide highly accurate tracking of bull trout spawner trends, especially for a core area of this size and complexity.

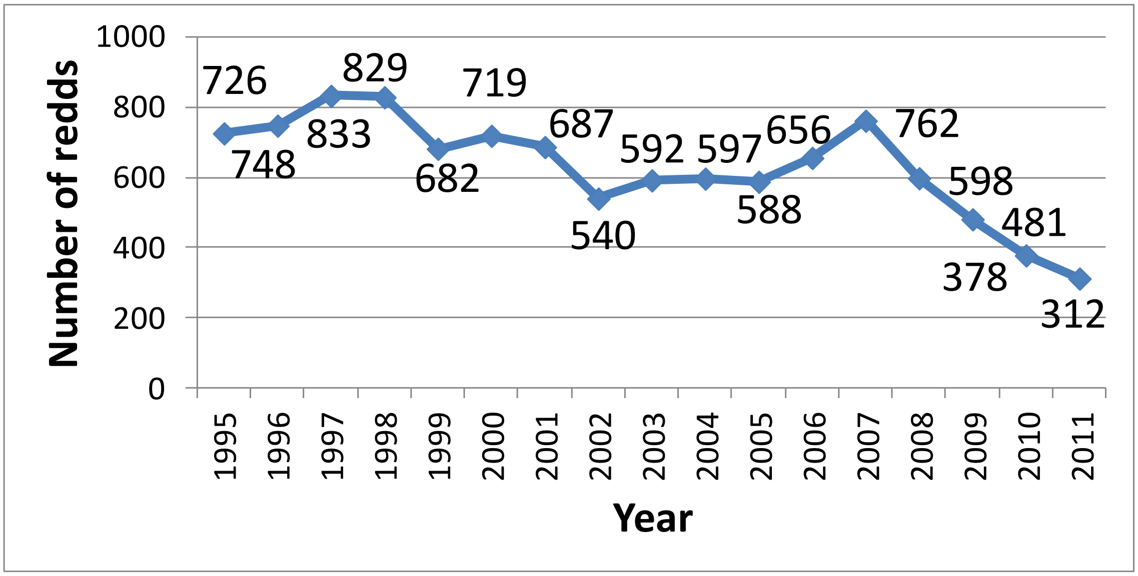

Figure 10: Swan Lake basin-wide bull trout redd counts 1995-2011.

The 1995 to present trend in basin-wide redd counts covers a period of relatively high bull trout population levels compared to historical condition for this core area, which is largely attributable to favorable conditions of an abundant forage base (primarily *Mysis* and kokanee) in Swan Lake, stable and improving habitat trend in the spawning tributaries, and restricted angling mortality. Angler harvest of bull trout declined (despite stable or increasing bull trout populations) from an estimated 482 bull trout in 1995 (Rumsey and Werner 1997) to an estimated 176 bull trout in 2009 (FWP unpublished), as fishing regulations were gradually tightened as well.

Additional data from comprehensive bull trout studies in the Swan Basin include work by Leathe and Enk (1985) and Leathe et al. (1985a, 1985b) which described physical and fishery attributes of the important bull trout spawning tributaries. Those reports determined that bull trout spawning populations in Swan tributaries were comprised, on average, of 38% Age 5, 36% Age 6, 20% Age 7, 6% Age 8, and <1% Age 9 and older bull trout. Those same studies contained extensive analysis of age and growth information for bull trout.

In 2007, we (Fredenberg and Rumsey, unpublished Benefit/Cost Analysis) also estimated, based largely on previous netting experience in Swan Lake that a lake trout gill net suppression effort conducted during midsummer (late August- early September) when most adult bull trout were up the river on spawning migrations would catch between 225-900 bull trout annually, with an expected mortality rate of netted fish between 10-25% and a maximum estimated bull trout mortality of 315 fish. We determined that this rate of bycatch mortality should be acceptable so that the project could proceed and further, that this rate of loss would likely not cause a decline in a bull trout population estimated at over 5,000 adults.

Bull Trout Bycatch Due to Lake Trout Gill Net Actions

During 2007 and 2008 continued experimental efforts occurred and from 2009-2011 the comprehensive three-year experimental lake trout removal effort previously described was conducted. The purpose of this section of the report is to analyze effects of the netting specific to the threatened bull trout. During the five years of netting (2007-2011) we captured a total of 1,523 bull trout in all net sampling efforts combined. Annual catch totals were 2007 = 378; 2008 = 240; 2009 = 264; 2010 = 299; and 2011 = 342. A small proportion (roughly 12%) of the total sample of bull trout were not measured, so those fish are omitted from further analysis and may account for some discrepancies between totals here and in the earlier section of the report. The annual ratio of lake trout to bull trout in the catch rose from 5.6:1 in 2007; 15.8:1 in 2008; 22.9:1 in 2009; 33.5:1 in 2010; but then declined to 15.9:1 in 2011, apparently in response to declining lake trout catch rather than major changes in bull trout numbers.

The cumulative size structure of measured bull trout (n = 1,317) collected in 2007-2011 (Figure 11), depicts a normal distribution. Roughly equal proportions of the total sample were observed in length groups <300 mm (24%), 300-399 mm (30%), and 400-499 mm (26%), with smaller proportions in the large adult population in 500-599 mm (15%) and >600 mm (<6%) length ranges.

There was a pronounced shift to smaller bull trout in the sample, when the chartered Juvenile Netting began in 2009 (Figure 11), as netting efforts became focused on juvenile lake trout in deeper water. The size range of captured bull trout also directly reflects net dimensions (especially mesh size) and is not necessarily directly representative of the size and age structure of the bull trout population. More than 60% of all bull trout captured (including both Juvenile Netting and Spawner Netting) in 2009-2011 were under 400 mm (16 inches) total length; considered subadults based on their size. Some of the changes in the structure of the bull trout population over time were a direct result of modifications to our methods that were constantly adapted to minimize bull trout bycatch.

In comparing the bull trout samples captured in the gillnetting efforts, those captured during Spawner Netting conducted in October and early November after adult bull trout had returned to the lake contained a much higher proportion of adult sized fish. Roughly two-thirds of the bull trout captured during Spawner Netting were mature size (i.e., presumably Age 6 and older and greater than 425 mm or 17 inches) specimens, up to half of which appeared, based on external characteristics, to be post-spawning adults that had recently returned to the lake from upriver spawning activity. Conversely, bull trout caught during Juvenile Netting, where nearly all sets were in deep water and with relatively small mesh, were heavily comprised (nearly two-thirds) of presumptive age class 3,4, and 5 subadult bull trout (< 425 mm), virtually all of which had not yet matured or spawned for the first time.

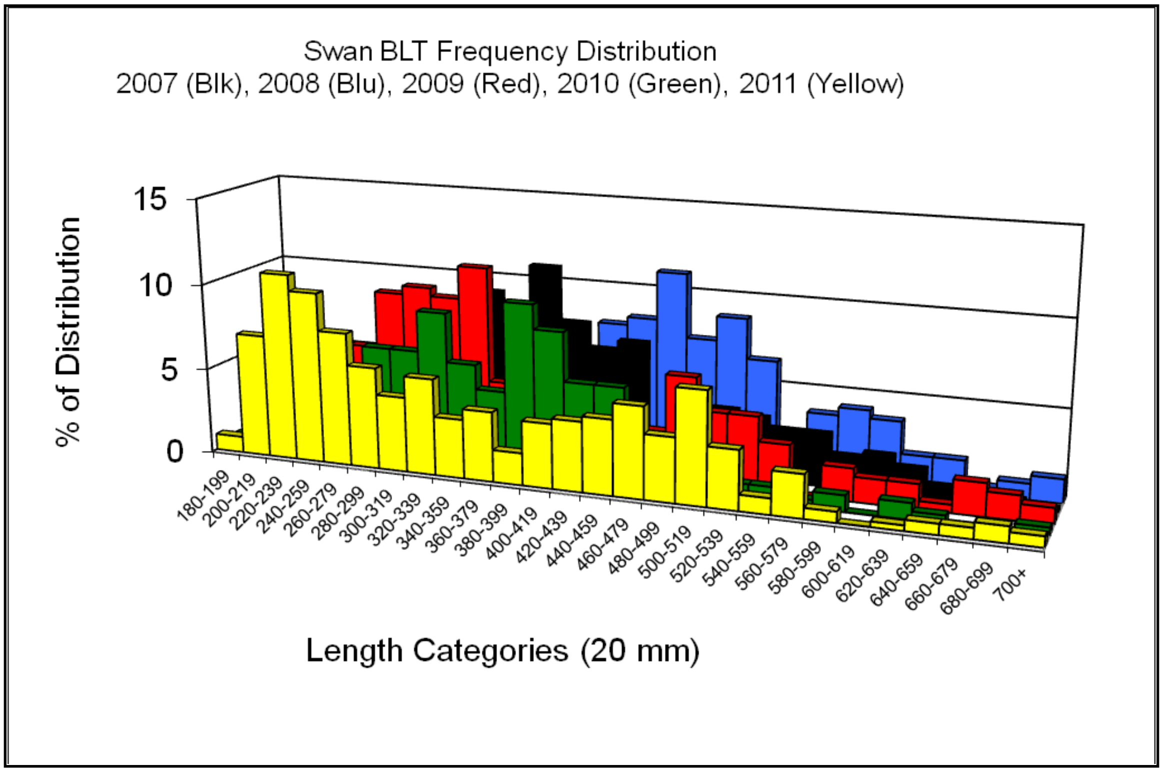

Figure 11: Relative length frequency (total length by 20 mm groups) of measured bull trout captured during lake trout suppression netting in Swan Lake 2007-2011.

We made an attempt to assess the potential impact to the bull trout population of selective losses to bycatch. As the redd counts have declined in recent years (Figure 10), there is appropriate concern that the netting could be a causative or contributing factor in the decline. In order to best evaluate this concern, we first estimated the ages of bull trout captured in the netting by back-correlating their sizes with the previous information on age and growth (Leathe and Enk 1985). We determined that roughly 10% of the total gillnetted sample was comprised of age 3 fish (181-248 mm or 7-9"); 24% were age 4 (249-337 mm or 10-13"); 25% were age 5 (338-427 mm or 14-17"); 22% were age 6 (428-518 mm or 18-20"); 12% were age 7 (519-611 mm or 21-24"); 5% were age 8 (612-694 mm or 25-27"); and 2% were age 9 or older (>695 mm or 28"). This presumes growth rates in recent times were similar to the mid-1980s, which is a reasonable assumption based on lake ecology and the size structure of bull trout observed in angler and gill net catches. As previously discussed, increased emphasis on lake trout spawner netting occurred over the 2009–2011 period, resulting in an increasing proportion of the annual bull trout bycatch (rising from 11% in 2009, to 29% in 2010 and 31% in 2011) occurring during these Spawner Netting events. The separate targeting of small and large fish during Juvenile and Spawner Netting periods, respectively, accounts for the noticeably bimodal distribution of bull trout exhibited in the 2011 netting results (in yellow, Figure 11).

By assuming captured bull trout were of known age, we were then able to assign individuals back to the spawning cohort from which they originated and reconstruct mortality estimates by age cohort (Table 3). We assumed that the combined netting affects six age classes of bull trout, ages 3-8. We discounted age-1 and age-2 fish that are in the tributaries and below sizes of recruitment to our nets, and also discounted age-9 and older fish because they are an insignificant portion of the population. Based on this approach, we observe that the netting, which began in 2007, first impacted considerable numbers of bull trout from the 1999 spawning cohort (those fish age-7 in 2007) and the most recent 2011 netting last impacted bull trout from the 2007 spawning cohort (those fish age-3 in 2011). In total, assuming all fish captured in gill nets die (which we know not to be true, but provides the worst-case scenario), the 2007-2011 netting program could have potentially removed between 75-281 bull trout from each of the 1999-2007 spawning year cohorts of fish (Note: bull trout that spawned in 1999 do not hatch until 2000 and are thus not considered to be age 1 until 2001, etc.). It is important to note that the bull trout cohorts currently impacted by the 2007-2011 gillnetting bycatch were all produced prior to the recent steep decline in bull trout redd counts that began in 2009.

Table 3: Bull trout spawning cohorts, basin-wide redd counts, and maximum mortality due to lake trout suppression netting.

Spawning Year	# Redds Basin-wide	Netting Bycatch of Cohort (# of bull trout)	Calculated Mortality (53.6% of bycatch) (# of bull trout)
1996	748	1	1
1997	833	8	4
1998	829	28	15
1999	682	86	46
2000	719	146	78
2001	687	281	151
2002	540	173	93
2003	592	142	76
2004	597	238	128
2005	588	142	76
2006	656	129	69
2007	762	75	40
2008	598	0	0
2009	481	0	0
2010	378	0	0
2011	312	0	0

There are multiple assumptions involved in this analysis. During sampling, we assess mortality of gillnetted and released bull trout by assigning each fish to one of four mortality categories. Class “0” = Mort (dead or moribund); Class “1” = Poor (not orienting, possible bleeding, respiration shallow); Class “2” = Fair (tired, but orienting and respiring, likely to survive); Class “3” = Good (vigorous, struggles to escape, energetically swims away upon release). For each of these mortality classes we have subjectively ascribed a rough estimate of survival probability. For Class “0” survival probability is nil. For Class “1” survival probability is 10-50% (average 30%). For Class

“1” survival probability is 51-90% (average 70%). For Class “3” survival probability is 91-100% (average 95%). During the progression of the netting surveys we have further enhanced survival of netted fish, particularly those in survival classes 1 and 2, by holding them for up to 30 minutes in an oxygenated, chilled, recirculation tank known as a Fraser Tank. There are instances where fish upon capture appear moribund, due to suffocation, but are observed to revive in the Fraser Tank to be released as Class 1 or 2.

Cumulatively, our 2007-2011 bull trout database includes 1,477 fish for which survival class was recorded (some fish in the total sample lacked a survival code). About 39.7% (n = 586) were direct mortalities, 8.5% (n = 125) were Class “1”, 13.9% (n = 206) were Class “2”, and the remaining 37.9% (n = 560) were Class “3”. By assigning the average survival to each class, we estimated total gill net mortality was 586 (Class “0”) + 88 (70% of Class “1”) + 62 (30% of Class “2”) + 56 (5% of Class “3”) = 792. Thus, our calculated estimate of total bull trout gill net mortality is 792/1,477 = 53.6% of the fish handled. In the last column of Table 3, we assigned 53.6% mortality to each cohort in order to better estimate the impact of mortality on the bull trout population. In 2010 we also began tagging all released bull trout with passive integrated transponder (PIT) tags in order to directly verify that survival was occurring and to further evaluate the survival classification scheme. Results are preliminary, but in 2010 and 2011 a total of 16 PIT-tagged bull trout were recaptured, 3 of which were Class “1”, 4 of which were Class “2”, and 9 of which were Class “3”.

Applying the same four-stage survival scale to the 1,497 bull trout in the catch resulted in a calculated total mortality by year associated with Juvenile Netting of 189 in 2007, 131 in 2008, 109 in 2009, 121 in 2010, and 133 in 2011 (Table 4). We began Spawner Netting in 2009 and calculated mortality for the 3 years of this netting event was 18 fish in 2009, 48 fish in 2010 and 49 fish in 2011. In cumulative, Juvenile Netting resulted in a calculated mortality of 683 fish and Spawner Netting added 115 for a grand total calculated mortality of 798 bull trout.

The overall impact of gillnetting-caused bycatch loss on the potential basin-wide bull trout redd production for the Swan Lake core area depends on the number of fish removed, their age (number of potential spawning years they could contribute), size (related to fecundity), sex ratio, whether or not spawning occurs annually, and whether or not compensatory mortality is occurring, as well as mortality rates and other factors. In the simplest model, we assume all spawners make an equal contribution (standard age, size, and sex ratio) and that there are 3.2 adults per redd (Fraley and Shepard 1989; Downs et al. 2006). Historical information indicated that adfluvial bull trout in Flathead Lake and similarly productive headwater systems such as Swan Lake were routinely alternate year spawners. Our recent Swan Lake data may somewhat refute that, at least at current population densities, as few adult-sized bull trout have been captured during the pre-spawning period (late August–early September) when our lake trout Juvenile Netting is occurring. This suggests that most Swan Lake bull trout at this time are either annual spawners and thus are upstream out of reach of the Juvenile Netting effort and/or those remaining in the lake are occupying shallower water (<60 feet) where nets are not set. Further, for purposes of this simple model, we assume that no compensatory mortality is occurring and that once bull trout reach age 3 no annual mortality is occurring. We assume that every bull trout that reaches the age of 5 spawns annually at ages 5, 6, 7, and

8; a generous and admittedly inaccurate assumption that would nonetheless maximize the potential production of an individual fish.

Applying these assumptions, we can calculate, year by year, the maximum projected loss of bull trout spawners and subsequent impact to redd counts due to gillnetting removal. In 2007, for example, when the project began, we estimated gill net mortality of 189 bull trout. Since all spawners were likely out of the lake by the time netting began, the impact on redds in 2007 (n = 762 basin-wide) would have been nil. To determine the impact in 2008, we would apply the average age class formula (10% age 3; 24% age 4; 25% age 5; 22% age 6; 12% age 7; 7% age 8+) to the calculated bull trout mortality from 2007 (n = 189) and estimate that 19 were age 3, 45 age 4, 47 age 5, 42 age 6, 23 age 7, and 13 age 8+ of the bull trout removed in 2007. Following through with similar analysis for each year, we produced the results displayed in Table 4.

We assume those fish age 4 and older in 2007 that we removed would have all survived to spawn (age 5 and older) in 2008, with the exception of those age 8 and older, which we eliminate due to senescence. In this fashion, 2007 gillnetting was estimated to remove 45+47+42+23 = 157 adult spawners from the 2008 population (Table 5). Converting this to redds: 157/3.2 = 49. Our conclusion, under this simplified model, is that the 2007 gillnetting removed a maximum estimated total of 49 redds from the 2008 basin-wide count. Similar calculations were performed annually. By this model, gillnet mortality of fish that were Age 4 in 2007 had the largest cumulative impact on Swan redd counts, as we assume noncompensatory mortality (and unrealistically low 0% annual mortality), meaning those fish would continue to affect the redd count baseline for four succeeding years (2008-2011).

Table 4: Calculated age-class structured bycatch mortality of bull trout for each year of lake trout suppression netting to date.

Year	Calculated Mortality (juv+spawn) =	Mortality Age Class 3 (0.10)	Mortality Age Class 4 (0.24)	Mortality Age Class 5 (0.25)	Mortality Age Class 6 (0.22)	Mortality Age Class 7 (0.12)	Mortality Age Class 8+ (0.07)
2007	189	19	45	47	42	23	13
2008	131	13	31	33	29	16	9
2009	109+18 = 127	13	30	32	28	15	9
2010	121+48 = 169	17	41	42	37	20	12
2011	133+49 = 182	18	44	45	40	22	13

With these calculated mortality by age class estimates, it’s further possible to summarize the potential loss of spawners for each spawning year and assess the theoretical contribution the suppression netting of lake trout may be contributing to the changes in basin-wide bull trout redd counts (Table 5).

Table 5: Calculated cumulative bycatch mortality loss of bull trout in relation to spawning year, for lake trout suppression netting to date.

Spawn Year	Bycatch Mortality Loss (5 years prior)	Bycatch Mortality Loss (4 years prior)	Bycatch Mortality Loss (3 years prior)	Bycatch Mortality Loss (2 years prior)	Bycatch Mortality Loss (1 year prior)	Bycatch Mortality Loss Cumulative
2008					45+47+42+23	**157**
2009				19+45+47+42	31+33+29+16	**262**
2010			19+45+47	13+31+33+29	30+32+28+15	**322**
2011		19+45	13+31+33	13+30+32+28	41+42+37+20	**384**
2012	19	13+31	13+30+32	17+41+42+37	44+45+40+22	**426**
2013	13	13+30	17+41+42	18+44+45+40		**303**
2014	13	17+41	18+44+45			**178**
2015	17	18+44				**79**
2016	18					**18**

Based on this analysis, we can observe the accumulating trend in the loss of potential spawners, which as discussed would have a maximum effect to bull trout after five consecutive years of netting. This is a high estimate because we know that adult bull trout mortality is higher than zero and we also suspect there may be some level of compensatory mortality occurring. Nonetheless, this estimate conservatively favors protection of the species. We can see from Table 5 that the maximum loss of bull trout spawners due to netting will not accumulate until spawning year 2012, when an estimated 426 spawners are removed from the bull trout population. Based on the current trend of bycatch, if netting continues in 2012 and beyond at similar intensity, we would anticipate the reduction of spawners would stabilize at about 426 spawners annually. Using the existing conversion factor of 3.2 adults per redd, a reduction of 426 spawners could cause at most a net reduction of about 133 redds per year in the Swan Lake bull trout core area.

Conclusions on Bycatch Assessment

Basin-wide bull trout redd counts have steadily declined over the past 4 years, since a peak of 762 redds were counted in 2007; down to 598 in 2008, 481 in 2009, 378 in 2010 and 312 in 2011. The latter figure represents a decline of nearly 60% from the recent 2007 peak. Based on our analysis, it appears the gillnetting bycatch is potentially contributing to this decline, but is not solely responsible for it. The reduction in redds attributable to bycatch mortality can be estimated by dividing the cumulative bycatch mortality (last column in Table 5) by 3.2 (# adults/redd). Thus, the bycatch potentially reduced redd counts by up to 49 in 2008, 82 in 2009, 101 in 2010, and 120 in 2011. As discussed, these are maximum estimates since we have chosen to discount annual and compensatory mortality and because we assumed that bull trout spawn annually. It is logical to conclude that the peak loss of bull trout redds due to bycatch will occur in 2012 at up to 133 redds, and should then stabilize since all age classes that contribute to redd counts will have been fished over. If the lake trout gillnetting program continues at existing levels, then bycatch of bull trout will contribute to the loss of up to 133 bull trout redds per year. If the gillnetting program were to be discontinued or reduced, impacts to the redd counts will still be felt through at least 2015, though at modified levels.

As redd counts decline, the effect of netting bycatch is proportionally more consequential to the bull trout population. Loss of 133 redds from a peak of 762 (as in 2007) would represent only 15% off the top, but loss of 133 redds from a count of 312 (as in 2011) represents nearly a 30% decline.

An alternative way to measure the impact of the loss of redds due to netting could be through the juvenile abundance surveys conducted annually by FWP in four primary spawning streams. A multi-pass population estimate of age 1 and older bull trout has been conducted more or less annually in the same sections of Elk, Goat, Lion, and Squeezer Creeks since 1987. Results are expressed in terms of fish/100m^2. A composite number is obtained by averaging the individual values for the streams surveyed. In 2001 through 2011 the composite average ranged from 2.26 to 4.64 bull trout / 100m^2 (FWP unpublished). There would be a time lag between redd counts and juvenile numbers because the index essentially measures the density of age 1 and age 2 fish. The 2011 composite estimate (2.26 bull trout / 100m^2) was the lowest of the last 10 years, but streamflows were also very high throughout the summer and conditions for survey were difficult, so that only two of the four index streams (Goat and Squeezer) were surveyed. In future years, it will be important to continue to collect this juvenile data as a potential early warning if populations begin to collapse. It is also not known whether these important local populations are fully seeded by the number of available spawners and whether thresholds may exist beyond which low numbers of spawners result in lower numbers of juvenile bull trout. In the late 1980s and early 1990s, redd counts similar to the range seen in the past 4 years produced composite juvenile abundance similar to the long-term average (3.45 bull trout / 100m^2).

Finally, in order to be proactive, FWP has closed the bull trout harvest fishery on Swan Lake, beginning March 1, 2012. In 1983-1984 the estimated angler harvest of bull trout from Swan Lake was 738 fish and as recently as 1995, estimated angler harvest was 482 fish. The harvest has continued to decline since then (attributable to tighter regulations and perhaps changing angler ethics in regard to bull trout), with an estimated harvest of only 176 bull trout in 2009. It is logical to assume that the angler harvest in recent years was additive to the bycatch mortality from netting and so by closing the harvest fishery we should gain some additional buffer. The recent level of angler harvest appears to have been roughly equivalent to the total number of bull trout removed (calculated bycatch mortality) with gill nets.

In conclusion, the bull trout bycatch associated with the lake trout gillnetting program, as it is currently configured (30 Juvenile Netting events followed by 20 Spawner Netting events), is likely to remain at around 300-350 fish per year, with roughly half those fish killed. The predicted population level impact of that removal is a maximum reduction of up to 133 bull trout redds per year from the system-wide total. Based on what we currently understand about bull trout population dynamics, that level of reduction should be sustainable and should not have long-term population level consequences. The recent redd count declines were steeper than what would be predicted by gill net bycatch. There is no way to feasibly determine the impact to bull trout from competition or predation by lake trout, but the removal of over 27,000 lake trout from the system (2007-2011) should benefit the bull trout population. Effective lake trout suppression will likely lead to a rebound in bull trout redd count numbers within 5-10 years (1-2 bull trout generations).

Data Analysis and Evaluation Criteria

This three-year removal project in Swan Lake was initiated to evaluate the efficacy of gill nets as a management tool to control the expansion of the lake trout population while minimizing the impact of these non-native fish on the bull trout and kokanee fisheries. Criteria to evaluate our actions were outlined in the 2009 EA. These criteria were as follow:

1. *Fisheries literature suggests that total annual mortality in excess of 50% has led to the collapse of lake trout fisheries in other regions. However, there is uncertainty, under circumstances for optimal population growth such as Swan Lake currently provides, whether an overfished lake trout population will collapse. Using this as a guideline, we propose to exert a level of effort that would result in at least 50% total annual mortality for three years, on both the subadult and adult components of the Swan Lake lake trout population. Based on results of the 2008 depletion population estimate, total fishing effort would require the removal of at least 4,850 fish (between 165-900 mm) to reach the mortality rate target in 2009, assuming no additional removal by anglers or by natural mortality. New estimates, based on annual recruitment, would need to be calculated annually but similar levels of effort will be required in 2010 and 2011. Additionally, netting aimed directly at the adult component of the population will be similarly evaluated by examining the number of radio-tagged fish captured during the spawning months (October-November). Success of this portion of the netting will also require removal of at least 50% of the adult fish.*
2. *Determining whether the 50% annual mortality is sufficient will be an important facet of this project. The intent of this level of effort is to reduce the lake trout population to a point in which negative effects to bull trout and kokanee are minimized. Therefore, trend data associated with the lake trout population will be assessed through several metrics. Lake trout catch per unit effort (CPUE) during both the lake-wide netting, as well as the focused spawner netting, will be monitored annually. Additionally, lake trout relative weights, and average length of spawning fish will also be monitored to detect changes associated with our actions. If our efforts are successful, lake trout CPUE should decline. Relative weights of lake trout should also remain stable or increase, and average length of spawning fish should decrease, other indicators signifying a reduction in larger, older fish. Another lake-wide population estimate will be conducted at the conclusion of this three-year effort to determine if the removal target translated into a significant reduction in lake trout abundance.*
3. *Maintaining stable fisheries for bull trout and kokanee is the ultimate goal for this project. Therefore, detecting trends in both the fish populations and the forage base they depend on will also determine the effectiveness of our actions. Bull trout will continue to be monitored through annual redd counts, juvenile estimates in index spawning tributaries, and through CPUE of both routine spring gill net samples, as well as during the lake-wide netting conducted by professional fisheries consultants. Kokanee numbers will continue to be monitored through*

annual redd counts, which have been conducted since 1987, as well as through CPUE in routine spring gill net sampling. Mysis shrimp represent a considerable forage base for juvenile bull and lake trout, and to a lesser degree provide forage for kokanee. Mysis densities have been monitored in Swan Lake since 1983, and will continue to be collected at standardized times and locations. Although the 3-year time period of this project may be insufficient to detect increases in any of these indices, substantial declines could be an indicator that lake trout removal efforts are not effective enough.

Considerable data was collected in 2009-2011 to address these predetermined evaluation criteria. Detecting change in any one of the three aforementioned evaluation criteria may or may not provide conclusive evidence with regard to our removal efforts. However, if the suite of indices all point toward a conclusion that our efforts have been successful, the results would lend credence to the thought that our actions are appropriate. Evaluation criteria numbers 1 and 2 represented the highest priority for this three-year project in determining the feasibility of suppressing lake trout. We concluded that if these objectives were satisfied, it was likely that risks to other fish species would be minimized. The following analysis pertains to the achievement of the criteria.

Data Analysis Methodology

Body condition

Relative weight (Wr; Anderson and Neumann 1996) was calculated by year for three ontogenetic length groups following maturity data from Cox (2010) and diet data from Guy et al. (2011). Lake trout length groups were defined as immature-planktivorous (280 - 499 mm or 11-20" total length), immature-piscivorous (500 - 699 mm or 21-27.5"), and mature-piscivorous (700 + mm or 28"). The standard weight (Ws) equation was from Piccolo et al. (1993): $\log_{10}$ Ws = -5.681 + 3.246 ($\log_{10}$ length), where length is measured in millimeters.

Abundance and exploitation

The abundance ($\hat{N}$) of lake trout targeted by juvenile netting (200–495 mm or 8-20" total length) was estimated annually using a multiple sampling period depletion estimator (Hayes et al. 2007). Netting did not occur on weekends; therefore, each of the three weeks of netting was considered a separate sampling period. An equal amount of effort was expended across sampling periods in 2008. For 2009 through 2011, the catch was adjusted to a constant level of effort by mesh size across sampling periods within each year. Exploitation (μ) was calculated annually as the catch divided by $\hat{N}$. Catchability (q) was calculated by year as the quotient of catch per unit effort (C/f; 1 unit of effort = 100m of net set for 1 hour) and estimated population abundance ($q = C/f \,/\, \hat{N}$); Quinn and Deriso 1999). Catchability represents the increase in exploitation achieved per unit increase in fishing effort (i.e., $\mu = q \cdot E$, where μ = exploitation, q = catchability, and E = fishing effort). Annual estimates of q were examined as a function of $\hat{N}$ using linear regression.

Abundance was not estimable for lake trout targeted by spawner netting (> 495 mm or 19.5" total length) because decreases in catch over sampling periods could be attributed to fish leaving the spawning sites rather than depletion. Survival (S) of spawning lake trout was estimated from the ratio of C/f for individual cohorts in successive years of spawner netting (Ricker 1975). Survival was estimated for lake trout from age-6 through 10 because lake trout were fully recruited to spawner netting at age-6 and there were fewer than 5 observations beyond age-10 (Ricker 1975). Survival of spawning lake trout was calculated as the geometric mean of cohort-specific survival rates from 2010 to 2011. Additional years (i.e., 2008 and 2009) could not be included because fishing methods varied. Survival was converted to total instantaneous mortality ($Z = -\log_e[S]$). Instantaneous fishing mortality (F) was estimated by partitioning total instantaneous mortality into natural and fishing components ($Z = F + M$; Miranda and Bettoli 2007) using the estimate of M from Cox (2010). Total annual mortality (A) was estimated as 1-S and exploitation was estimated as $\mu = F \cdot A/Z$ (Miranda and Bettoli 2007).

Evaluation Criteria Results and Discussion

Body Condition

Relative weight of immature-planktivorous lake trout increased from 2007 to 2009, and then declined in 2010 and 2011 (Figure 12). Interestingly, Wr of immature-planktivorous lake trout was not correlated with *Mysis diluviana* abundance (Figure 13). The lack of a correlation could be related to the accuracy of the *Mysis diluviana* abundance data. Abundance of *Mysis diluviana* is only measured at two locations in Swan Lake (i.e., the North and South) and these locations may not fully represent the *Mysis diluviana* population. It is also likely that *Mysis diluviana* abundance is not limited by lake trout because lake trout abundance is below carrying capacity. Alternatively, other species such as bull trout and kokanee consume *Mysis diluviana*, which may influence the abundance of *Mysis diluviana* and confound the relationship.

Relative weight for immature-piscivorous lake trout and mature-piscivorous lake trout declined approximately ten Wr units from 2007 to 2011 (Figure 12). Relative weight did not change between 2010 and 2011 for the two piscivorous ontogenetic length groups. Relative weight of both ontogenetic length groups was significantly correlated with abundance of kokanee redds (Figure 14). The lake trout Wr data in Figure 12 is the year prior to the kokanee redd count data because we assume most kokanee are available as prey to lake trout before the kokanee become sexually mature. Thus, the influence of lake trout on the abundance of kokanee (as index by redd counts) is observed at least one and possibly two years later in the kokanee redd counts.

Abundance and exploitation

Abundance estimates for 200-495 mm (8-20") lake trout increased from 7857 (7841 - 7871; 95% CI) in 2008 to 9339 (9053 - 9625; 95% CI) in 2010 and declined to 6096 (5981 - 6210; 95% CI) in 2011 (Figure 15). Because these abundance estimates were calculated using the rate of depletion during Juvenile Netting, the estimates describe the number of lake trout present prior to removal of that given year. Exploitation of 200-

495 mm (8-20”) lake trout increased from 0.44 in 2008 to 0.87 in 2011 (Table 6). Total annual mortality rates were generally higher than the target of 0.5 and increased from 0.49 in 2009 to 0.89 in 2011 (Table 6). Catchability for juvenile netting increased as a linear function of abundance (Figure 16), indicating that efficiency decreases with declining lake trout abundance. The catchability estimate for 2008 was an outlier and was removed from the regression analysis. The average survival rate for age-6 through 10 lake trout was 0.28 (0.20 - 0.36; 95% CI) from 2010 to 2011, corresponding to an exploitation rate = 0.68 (0.57 - 0.76; 95% CI) and total annual mortality = 0.72 (0.62 - 0.80, 95% CI). Total annual mortality for spawners is higher than the target of 0.5; however, this value needs to be interpreted with caution given the paucity of data on the cohorts included in the analysis. Additional years of *C*/*f* data will increase the credibility of the estimate.

These data indicate that the suppression program is exceeding the target of 0.50 total annual mortality for juvenile and mature lake trout in Swan Lake. The literature indicates that lake trout suppression is likely at the observed exploitation levels in 2009, 2010, and 2011 (Martin and Olver 1980). The lack of a response in kokanee redd counts and Wr of piscivorous lake trout should not be surprising given the short time the suppression program has been in operation. Suppression of non-native species takes time given the ‘build-up’ of the species prior to implementation of the suppression effort. Thus, we predict a positive biological response will be observed in kokanee redd counts and Wr of the few remaining lake trout within the next five years, if suppression efforts equal or surpass current exploitation estimates and environmental conditions are similar. This predicted response presumes that kokanee numbers are controlled by predation levels from lake trout and bull trout and not from angling or other environmental factors.

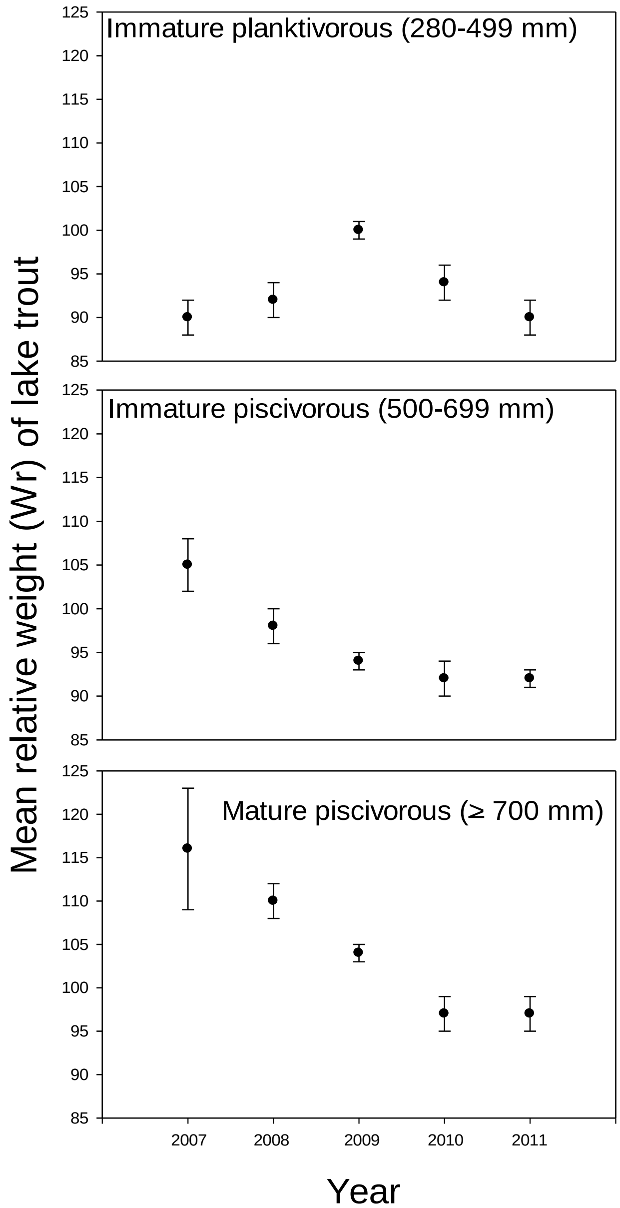

Figure 12: Relative weight (W_r) by ontogenetic length group and year for lake trout in Swan Lake, Montana. Error bars delineate 95% confidence intervals.

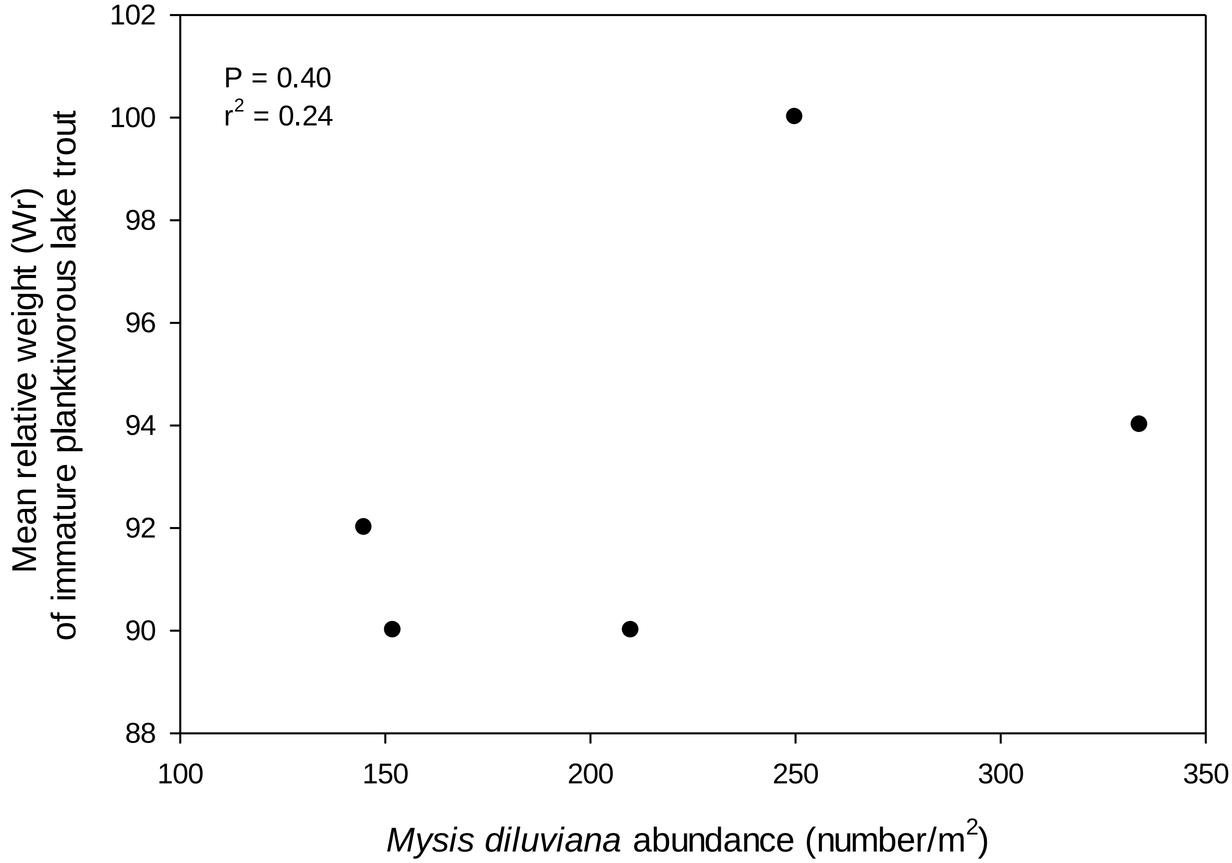

Figure 13: Relation between *Mysis diluviana* abundance and mean relative weight (Wr) of immature planktivorous lake trout (280-499 mm or 11-20") from 2007 to 2011 in Swan Lake, Montana.

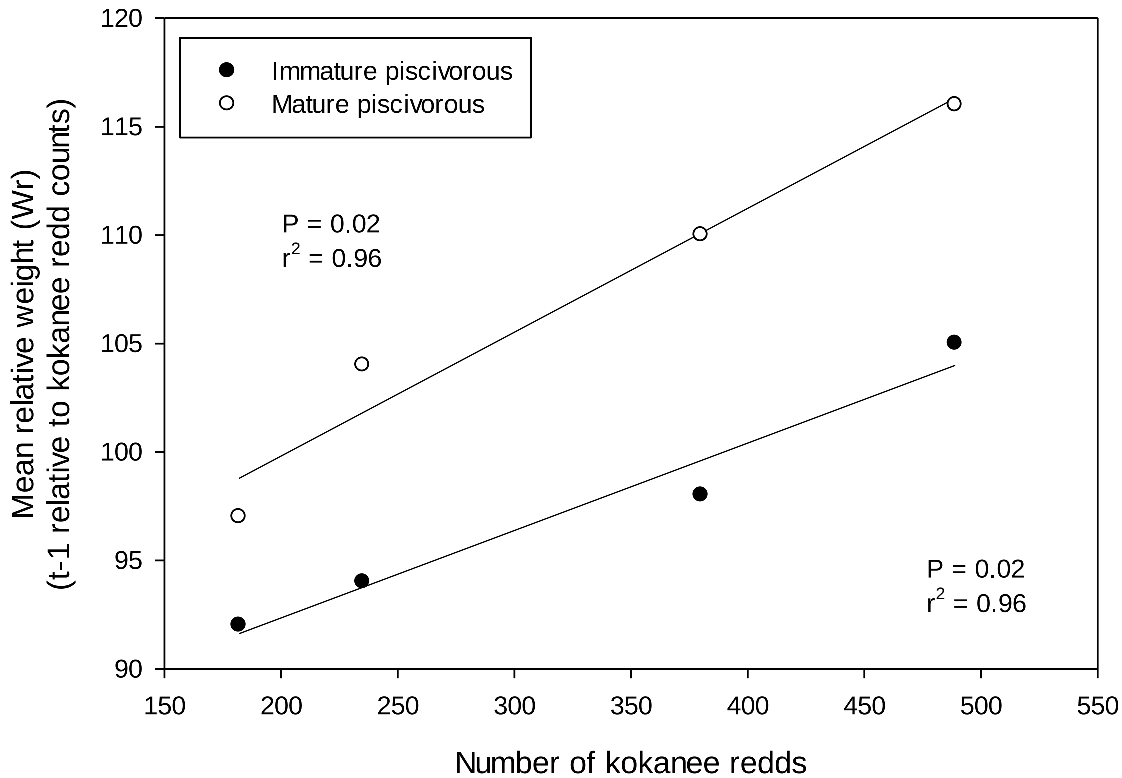

Figure 14: Relation between number of kokanee redds (index to kokanee abundance) and mean relative weight (Wr) of immature piscivorous lake trout (500-699 mm or 21-27.5") and mature piscivorous lake trout (≥ 700 mm or 28"). Data for lake trout (2007-2010) are one year previous of the kokanee redd count data (2008-2011; see text for explanation) and all data are from Swan Lake, Montana.

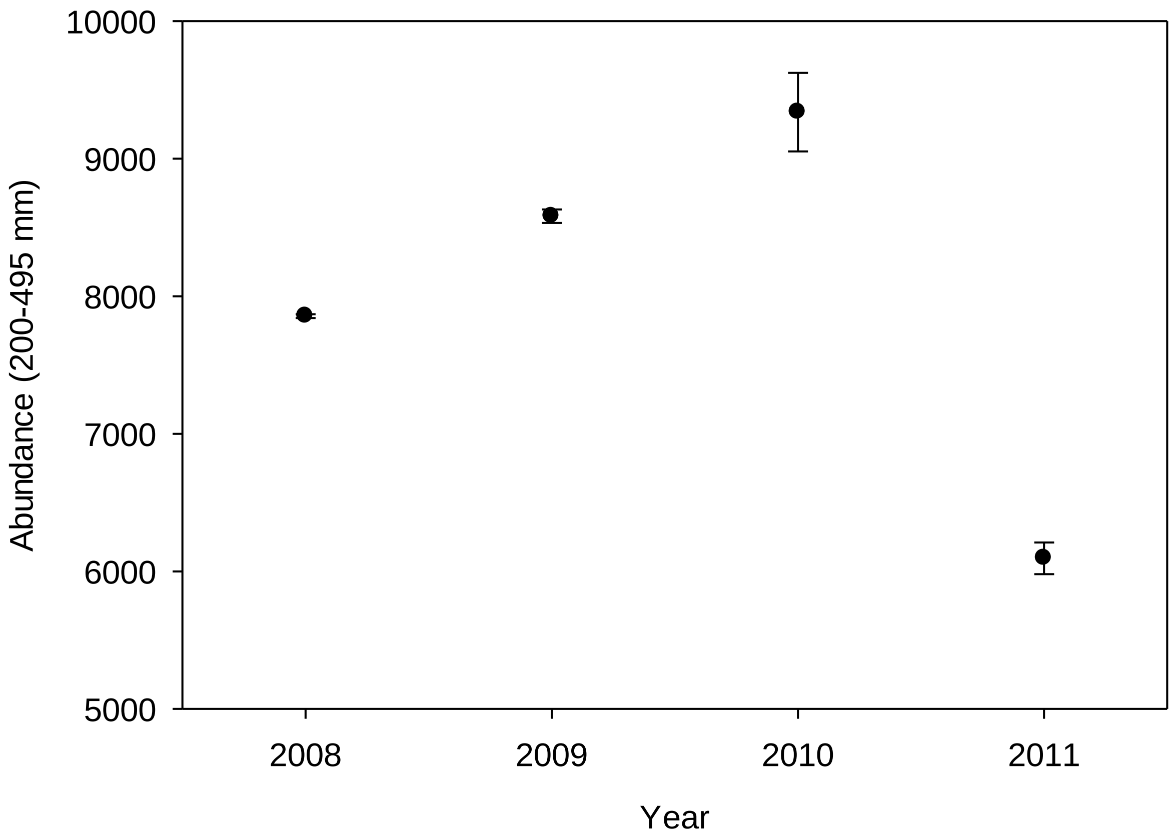

Figure 15: Depletion abundance estimates for 200-495 mm (8-20") lake trout from 2008 to 2011 in Swan Lake, Montana. Error bars delineate 95% confidence intervals.

Table 6 : Estimates of exploitation and total annual mortality for 200-495 mm (8-20") lake trout in Swan Lake, Montana from 2008 to 2011.

Year	Exploitation (95% CI)	Total annual mortality (95% CI)
2008	0.446 (0.445, 0.446)	0.490 (0.489, 0.491)
2009	0.702 (0.699, 0.706)	0.726 (0.722, 0.730)
2010	0.946 (0.912, 0.976)	0.950 (0.924, 0.977)
2011	0.877 (0.861, 0.894)	0.887 (0.872, 0.902)

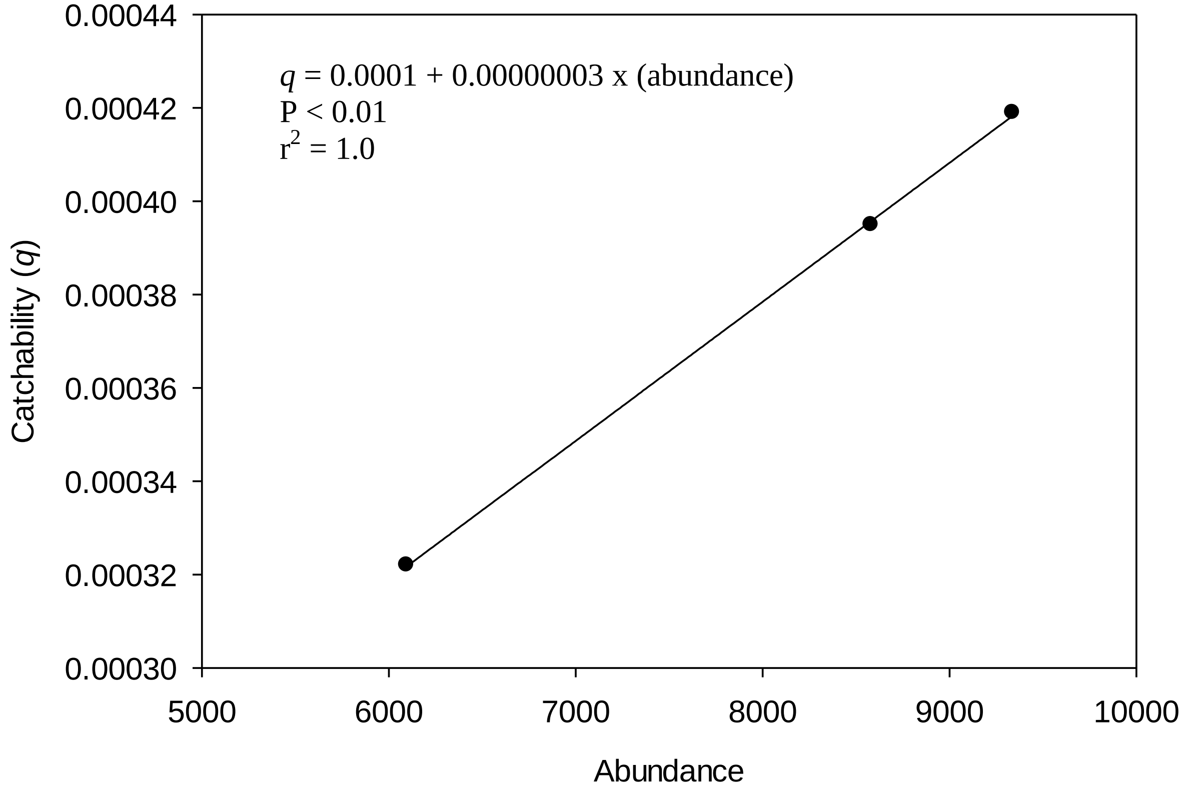

Figure 16: Catchability (*q*) as a function of abundance for 200-495 mm (8-20”) lake trout from 2009 to 2011 in Swan Lake, Montana. The product of *q* and fishing effort (1 unit = 100 m of net set for 1 hour) equals the exploitation rate.

Bull trout (left) and lake trout (right) collected in Swan Lake. Notice the deeply forked tail of the lake trout and the pink spotting of the bull trout, both definitive traits in proper identification.

Conclusion and Recommendations

The three-year experimental removal of lake trout in Swan Lake represents one of the best test-cases for the use of gill nets as a tool to efficiently reduce lake trout abundance while minimizing impacts to other fish species. The relatively small size and simple bathymetry of the lake coupled with the early stage of lake trout establishment make Swan Lake a best case scenario to test the feasibility of this action plan. Additionally, Swan Lake still contains robust populations of bull trout and kokanee, both ecologically and recreationally important fish species. Maintaining viable populations of these two species capable of supporting a recreational fishery is of the utmost importance. While much has been learned to date regarding our ability to affect year to year lake trout cohort strength, the overall effect our actions have had on the long-term population trajectory of the lake trout population remain unknown.

Fisheries managers throughout the western United States are increasingly tasked with conservation of native fish species adversely affected by the introduction of lake trout. Currently, lake trout suppression programs are being implemented in neighboring states (Idaho and Wyoming) and much insight with regard to the effectiveness of gillnetting can be gained from their work. However, both Yellowstone Lake and Lake Pend Oreille are considerably larger than Swan Lake and any inference the results of the aforementioned two projects have with regard to smaller systems (e.g., Swan Lake, Quartz Lake, etc.) is limited. Therefore, this research project represents a progression in informing what size and types of lakes are best suited to successful lake trout suppression efforts.

Initial results from this three-year gillnetting experiment have revealed that fishing mortality rates during Juvenile Netting are higher than literature suggests lake trout populations can sustain. Additionally, Spawner Netting results from Swan Lake indicate that fishing mortality is relatively high, though confidence in this metric will likely improve with more years of data. Length-frequency analysis reveals that both Juvenile and Spawner Netting have been effective at shifting both demographics toward smaller fish, suggesting that gillnetting has affected individual cohorts of lake trout.

These results are of particular interest, as some other lake trout suppression projects have either failed to establish baseline data to support these types of analyses or have exerted a level of effort insufficient to create this high of mortality rates.

The status of the Swan Lake bull trout and kokanee fisheries remain a significant concern for fishery managers. While lake trout represent much of the data found in this document, the overarching goal of the project is improve conditions for bull trout and kokanee. Therefore, bull trout bycatch continues to be a particular concern for any future efforts. Our analysis of the bull trout bycatch suggests that netting can have a potentially negative effect on their numbers. However, the regulation change effective March 1, 2012 should offset this impact if netting efforts are continued. Recent monitoring by FWP depicts declines in both the kokanee and bull trout populations. While bycatch is likely partially responsible for these declines, the overall effect attributed to lake trout predation and competition may be a bigger driver. Although these declines are concerning in the near term, continued monitoring of these two fishes may provide measures of success if increases are observed in subsequent years.

The SVBTWG began this three-year experiment as a feasibility study to determine if gill nets can be an effective tool are reducing both the number of lake trout and the effect they have on bull trout and kokanee. Results from 2009-2011 suggest that this may be an effective tool. However, there remains some uncertainty with regard to the overall effect this action has had on the lake trout population and whether this level of effort can be sustained without causing undue harm to bull trout through inadvertent bycatch. If netting is continued, results in the upcoming years will likely reveal whether past actions have resulted in a reduction in lake trout abundance, as a three-year lag time is present due to net selectivity. Because Spawner Netting did not begin until 2009, results from that sampling would not be observed until 2012 at the earliest, as juvenile lake trout do not recruit to the nets until they are three years old.

A key to effective lake trout suppression is to attack the problem on multiple fronts, not only fishing out the juvenile population of lake trout that were "in the pipeline" prior to the initiation of the suppression activity, but also removing the current spawners that supply eggs that will lead to future year classes. Therefore, it is our recommendation that the project be continued to allow scientists to draw inference from our past actions. As stated previously, this project represents one of the best test-cases with regard to lake trout suppression. A continuation of these efforts will not only provide valuable insight into how fisheries professionals address undesirable fish species, but will also provide some protection of our native and recreational fisheries until long-term management alternatives can be developed.

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